METHOD FOR MANUFACTURING A TURBOCHARGER ASSEMBLY HAVING A THERMALLY DECOUPLED FLANGE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. Application No. 10/376,048, filed February 26, 2003, which is hereby incorporated herein in its entirety by reference.

FIELD OF THE INVENTION

The present invention relates generally to a housing with a mounting flange for connecting the housing to another device and, more particularly, the invention relates to a center housing with a mounting flange for connecting the center housing to a turbine housing of a turbocharger.

BACKGROUND OF THE INVENTION

Turbochargers for gasoline and diesel internal combustion engines are devices known in the art that are used for pressurizing or boosting the intake air stream of the engine by using the flow of hot exhaust gas exiting the engine. The turbocharger typically includes a turbine housing with an inlet that receives exhaust gas exiting the engine such that the exhaust gas spins a turbine in the turbine housing. The turbine is mounted in the turbine housing on a shaft that is common to a radial air compressor housed in a compressor housing. Thus, rotary action of the turbine also causes the air compressor to spin within the compressor housing. The spinning action of the air compressor causes intake air to enter the compressor housing and to be pressurized or boosted a desired amount before it is mixed with fuel and combusted within a combustion chamber of the engine.

Certification under 37 C.F.R. §1.10
This correspondence is being filed by Express mail addressed to
Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450
on Date: December 12, 2003
Express Mail No.: EU832029909US

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The turbine and compressor housings are typically mounted on first and second opposite sides of a center housing. The shaft extends between the turbine and the compressor through a bore in the center housing. An annular area of the first side of the center housing that extends around the shaft can be exposed to the inside of the turbine housing and, hence, the hot exhaust gas passing therethrough. The center housing also has a turbine mounting flange that extends radially outward from the first side of the center housing and is bolted to the turbine housing.

The center housing can define one or more lubricant passages for providing lubricant to the shaft and one or more coolant passages for circulating a coolant fluid such as water. The coolant passage can be an annular passage in the center housing that is proximate to the first side of the center housing and to the turbine housing. As a result of the difference in temperature between the hot exhaust gas in the turbine housing and the relatively cool lubricant and/or coolant fluid in the passages, high thermal gradients result in the center housing causing thermal stresses to develop. Thermal stress can also result from the temperature variations that occur over time during operation of the turbine. For example, the center housing is exposed to thermal transients, or variations, due to changes in the engine exhaust gas temperature over time that occur during normal engine operation. These thermal transients typically result in alternating cycles of heating and cooling of the center housing. During the heating cycles, the center housing can become hot enough to plastically deform, and stresses in the center housing that occur during the cooling cycles can be great enough to cause cracks to form. The likelihood of cracking or other stress damage is often greatest near features in the center housing, such as bolt holes that are provided in the mounting flange. Further, when liquid coolants such as water are circulated through the coolant passage, the higher cooling effect can result in even greater thermal gradients and greater or faster temperature variations in the center housing, thereby increasing the stress in the center housing and increasing the likelihood of cracking. Cracks

that originate in the mounting flange can cause the housing to leak or otherwise fail.

Thus, there exists a need for an improved center housing that is characterized by reduced thermal stresses resulting from temperature variations during heating and cooling and from thermal gradients that exist between the hot exhaust gas and the relatively cooler lubricant and/or cooling fluid. The center housing design should reduce the likelihood of cracking or other failure of the center housing, for example, when cool liquid coolants are circulated through passages in close proximity to the first side of the center housing, which is exposed to the hot gas from the turbine housing.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Having thus described the invention in general terms, reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

Figure 1 is an elevation view illustrating a turbocharger assembly having a turbine housing and center housing according to one embodiment of the present invention;

Figure 2 is an orthogonal elevation view illustrating the left side of the turbocharger assembly of Figure 1;

Figure 3 is an elevation view illustrating the right side of the center housing of the turbocharger assembly of Figure 1; and

Figure 4 is a section view of the center housing of Figure 3 as seen along line 4-4 of Figure 2.

DETAILED DESCRIPTION OF THE INVENTION

The present invention now will be described more fully hereinafter with reference to the accompanying drawings, in which some, but not all embodiments of the invention are shown. Indeed, this invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will

satisfy applicable legal requirements. Like numbers refer to like elements throughout.

Referring to Figures 1 and 2, there is shown a turbocharger assembly **10** according to one embodiment of the present invention, including a turbine housing **20** and a center housing **40**. A first side of the center housing is connected to the turbine housing and a second side of the center housing is configured to be connected to a compressor housing (not shown) for a compressor. A turbocharger formed by connecting a compressor to the assembly **10** can be used in conjunction with a gasoline or diesel internal combustion engine to pressurize the intake air stream of the engine by using the flow of hot exhaust gas exiting the engine. One turbocharger is further described in U.S. Patent No. 5,947,681 to Rochford, the entirety of which is incorporated herein by reference. The center housing **40** can also be used in other applications, with or without the use of the other components of the turbocharger. Each of the components of the turbocharger assembly **10** can be formed of any of a variety of materials including, but not limited to, cast iron, steel such as stainless steel, aluminum, metal alloys, ceramics, and the like. The components can be formed of the same materials, or each component can be formed of different materials.

As illustrated in Figure 1, the turbine housing **20** has an inlet **24** for receiving exhaust gas that is exiting the engine. The exhaust gas flows through the turbine housing **20** to an outlet **26**, rotating a turbine (not shown), which is rotatably mounted in the turbine housing **20** on a shaft **12**. The shaft **12** extends through an aperture in the turbine housing **20**, through a shaft bore **42** (Figure 4) defined by the center housing **40**, and into the compressor housing where the shaft **12** engages the compressor. Thus, as the exhaust gas causes the turbine to rotate, the turbine rotates the air compressor via the shaft **12**, thereby causing the air compressor to pressurize air that is then mixed with fuel and combusted in the engine.

The center housing **40**, shown individually in Figures 3 and 4, has a body **44** with first and second sides **46**, **48** that are configured to be connected to the turbine housing **20** and compressor housing, respectively. As shown in Figure 2,

connection features **50** such as bolt holes can be provided on the second side **48** of the housing body **44** for connecting the housing body **44** to the compressor housing. The shaft bore **42** extends between the first and second sides **46**, **48** and receives the shaft **12** extending between the turbine and the compressor. A lubricant passage **52** extends from an outer surface **54** of the housing body **40** to the shaft bore **42** such that lubricant can be provided to the shaft **12** during operation of the turbocharger. The lubricant passage **52** extends between an inlet **51** and an outlet **53** and can deliver lubricant, for example, to bearings (not shown) that are provided in the bore **42** for supporting the shaft **12** therein. The first side **46** of the housing body **44** is defined by a central block portion **56** of the housing body **44**. The central block portion **56** can be generally smaller in diameter than the remaining portion of the housing body **44**, i.e., the portion of the housing body **44** that is between the central block portion **56** and the compressor housing.

As shown in Figure 4, the housing body **44** defines a coolant passage **58** through which coolant fluid can be circulated to control the temperature of the center housing **40**. The coolant passage **58**, which can be disposed in the central block portion **56** of the housing body **44**, extends from an inlet **60** to an outlet **62** (Figure 1), both of which can be connected to a pump or other device for circulating the fluid, as is known in the art. The coolant can be a gas, such as air. In one advantageous embodiment of the invention, the coolant is a liquid such as water, which is generally capable of absorbing more thermal energy from the center housing **40** than air.

A mounting flange **70** extends in a generally radial direction from the housing body **44**, e.g., from the central block portion **56**, for mounting or connecting the center housing **40** to the turbine housing **20**. The mounting flange **70** can be formed as an integral part of the housing body **44**, and the flange **70** can include a connection portion **72** that defines one or more connection features **74** such as bolt holes or pin holes for receiving bolts, pins, or other connection devices that extend into corresponding holes or otherwise engage features in the turbine housing **20**. The mounting flange **70** also defines a curved portion **76** that extends circumferentially around at least part of the housing body **44** and is

disposed between the housing body **44** and the connection portion **72**. At least a portion of the circumference of the flange **70** is curved or c-shaped in cross-section, with the curved portion **76** extending generally radially outward from the housing body **44**, and the connection portion **72** extending further radially outward from the curved portion **76**. The curved portion **76** of the mounting flange **70** has a generally c-shaped cross-section defined by c-shaped inner and outer surfaces **78**, **80**, such that the curved portion **76** defines a space **82** between the housing body **44** and the connection portion **72**. As illustrated in Figure 3, the c-shaped curved portion **76** can extend circumferentially around the housing body **44** so that the space **82** is annular around the housing body **44**. In other embodiments, the curved portion **76** can extend only partially around the housing body **44** at one or more circumferential positions, for example, so that the curved portion **76** is disposed proximate to holes or other features **74** in the connection portion **72**.

The inner surface **78** of the curved portion **76**, as well as the first side **46** of the housing body **44**, can be exposed to the exhaust gases in the turbine housing **20** through the aperture in the turbine housing **20**. Thus, the center housing **40** is contacted and heated by the turbine housing **20** and the exhaust gas, which can reach temperatures of 1450 °F or higher. The center housing **40** is cooled by the coolant fluid circulated through the coolant passage **58**, which is typically about 250 °F, and by the lubricant. The center housing **40** can also be cooled, though usually to a lesser extent, through convection by air outside the center housing **40**. Due to the temperature difference between the hot exhaust gas in the turbine housing **20** and the relatively cool fluid in the coolant passage **58**, a spatial thermal gradient exists in the center housing **40**. For example, a temperature difference of about 1200 °F can exist in the center housing **40** over a distance of 3 inches or less, though the actual thermal gradient, or temperature difference per unit length, is usually complex, having different values at different locations throughout the center housing **40**.

The center housing **40** can be formed of various types of materials. In some cases, the material may have properties enabling it to resist cracking or other failure when subjected to the thermal gradient. However, in other cases the center

housing **40** may be formed of a material that is susceptible to cracking when the thermal gradient is coincident with portions of the center housing **40** where stress concentrations are likely to occur, such as bolt holes. For example, the center housing **40** can be formed of cast iron, which can be strong enough to undergo repeated stresses associated with thermal gradients, especially if a large annular flange is provided for connecting the center housing **40** to the to the turbine housing **20**. However, the cast iron of the center housing **40** can be susceptible to cracking by the thermal gradients if the gradients are coincident with a bolt hole or other geometric feature that concentrates stress.

The curved portion **76** of the mounting flange **70** at least partially thermally decouples the connection portion **72** of the flange **70** from the housing body **44**, i.e., the curved portion **76** at least partially isolates the connection portion **72** from thermal effects in the housing body **44**. Thus, although high temperatures may develop in the connection portion **72**, the maximum temperature difference, and hence the maximum thermal gradient, in the connection portion **72** of the flange **70** is substantially less than that in the housing body **44**. For example, if the temperature difference between the exhaust gas and the coolant fluid is about 1000 °F, the temperature difference throughout the connection portion **72** of the flange **70** is typically less than about 100 °F, while the temperature difference throughout the housing body **44** can be several times as great. Further, the temperature difference is typically even less in each local area that surrounds the connection features **74** in the connection portion **72**. Therefore, the high stresses associated with the thermal gradient are not substantially coincident with the connection features **74** in the connection portion **72** of the flange **70**, and the likelihood of failure, such as by cracking near the connection features **74**, is reduced. It is understood that some thermal gradient may be present in the connection portion **72** and that the magnitude of the thermal gradient present in the connection portion **72** may vary according to such factors as the shape and dimensions of the housing body **44** and mounting flange **70**, the material used to construct the housing body **44** and the mounting flange **70**, the

location of the coolant passage **58**, the temperatures and flow rates of the exhaust gas and coolant fluid, the type of fluid coolant, and others.

The curved portion **76** of the mounting flange **70** also increases the flexibility of the flange **70**, which leads to a decrease in the stresses caused by thermal variations throughout the center housing **40**. During normal operation of the turbocharger, the center housing **40** can undergo repeated thermal variations, i.e., temperature changes over time. For example, when exhaust gas begins to flow through the turbine housing **20**, the turbine housing **20** and the center housing **40** are heated. The temperature of all or part of the center housing **40** can fall, for example, when the temperature of the exhaust gas from the engine decreases, as typically occurs cyclically during normal operation. Such temperature variations can result in thermal expansion or contraction of the center housing **40** and/or thermal stress in the center housing **40**. However, because the curved portion **76** of the flange **70** is disposed at least partially outside a radial plane defining the connection portion **72**, thermal expansion and contraction of the flange **70** can occur in a non-radial direction, e.g., in an axial direction perpendicular to the plane of the connection portion **72**. Thus, the shape and size of the flange **70** can change without corresponding movement of the connection portion **72** of the flange **70**, and the resulting stress in the connection portion **72** of the flange **70** is reduced.

Many modifications and other embodiments of the invention set forth herein will come to mind to one skilled in the art to which this invention pertains having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. Therefore, it is to be understood that the invention is not to be limited to the specific embodiments disclosed and that modifications and other embodiments are intended to be included within the scope of the appended claims. Although specific terms are employed herein, they are used in a generic and descriptive sense only and not for purposes of limitation.